Department of Chemical Engineering
Assignment No.1

Subject: Process Control   Semester: 6th, Chemical Engineering

Q.1 Draw a block diagram for the control system generated when a human being steers an automobile.

Q2. Solve using Laplace transform: $\frac{d^2x}{dt^2}+\frac{dx}{dt}+x=1$, when $x(0)=x'(0)=0$.

Q3. Solve using inverse Laplace: $\frac{3s}{(s^2+1)(s^2+4)}$

Q4. Obtain y*(t)* for the function $y(s)=\frac{s+1}{s^2+2s+5}$

Q5. If a forcing function f(t) has the Laplace transform $f(s)=\frac{1}{s}+\frac{e^{-s}-e^{-2s}}{s^2}-\frac{e^{-3s}}{s}$ graph the function f(t)

Department of Chemical Engineering

Assignment No.2

Subject: Process Control Semester: 6th, Chemical Engineering

Q1 A bare thermocouple, initially at 30^0C is moved at time t=0 in an air stream maintained at 50^0C. The thermocouple reads 42.65^0C at the end of 10 seconds. Assume steady state gain to be unity. This thermocouple is used to measure the temperature of the same air stream flowing at the same rate when its temperature is increasing at the rate of 3^0C per minute. What are the lag and the dynamic error shown by the thermocouple?

Q2. A thermocouple with a time constant of 2 seconds is used to measure the temperature of an air stream which is varying sinusoidal. If the indicated temperature is found to oscillate between 50^0C and 30^0C with a cycle time of 36 seconds, calculate the actual maximum and minimum temperatures of the air stream. Assume, steady state gain to be unity (K=1).

Q3. A thermometer is placed in a water bath kept at 50^0C and allowed to reach equilibrium. At time t =0, it is quickly transferred to another bath kept at 60^0C, kept there for 8 seconds and returned to the bath 50^0C. What will be the thermometer reading 5 seconds after it is returned to the bath at 50^0C? The time constant is 10 s.

Q4. A first order element requires I minute to indicate 98 per cent of a unit step input response and subsequently remains in -2 per cent error thereafter .What is the maximum frequency at which it will remain 5 per cent inaccurate ?

Q5. A thermometer is placed in an air stream flowing at 5 m/s. The temperature of the stream is subjected to a step change from 10^0C to 20^0C. The time required for 90 per cent recovery is 11.5 seconds. If the velocity is doubled, the time for 90 per cent recovery for the same step change is 6.9 seconds. Determine 'n' in the following expression

$$h=k* u^n$$

Where h is the heat transfer coefficient, k is a constant and u is the velocity of the air stream. Assume steady state gain, for the thermometer is to be unity.

Department of Chemical Engineering
Assignment No.3

Subject: Process Control Semester: 6th, Chemical Engineering

Q1. Find the transfer function Y(s) /X(s) of the system shown in Fig. 1

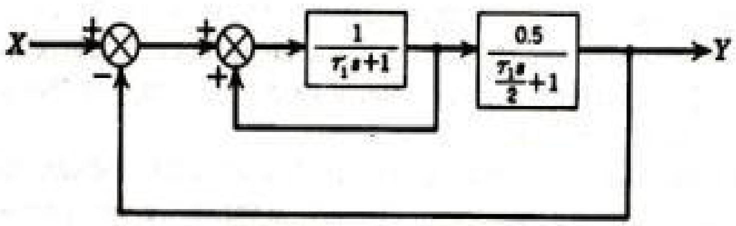


Figure 1

Q2. The control system shown in Fig. 2 contains three-mode controller.

(a) For the closed loop, develop formulas for the natural period of oscillation τ and the damping factor C in terms of the parameters K, τ_D , τ_I and τ_1 . For the following part, τ_D = τ_I=1 and τ1=2,

(b) Calculate C when K is 0.5 and when K is 2.

(c) Do C & τ approach limiting values as K increases, and if so, what are these values?

(d) Determine the offset for a unit step change in load if K is 2.

(e) Sketch the response curve (C versus t) for a unit-step change in load when K is 0.5 and when K is 2.

(f) In both cases of part (e) determine the max value of C and the time at which it occurs.

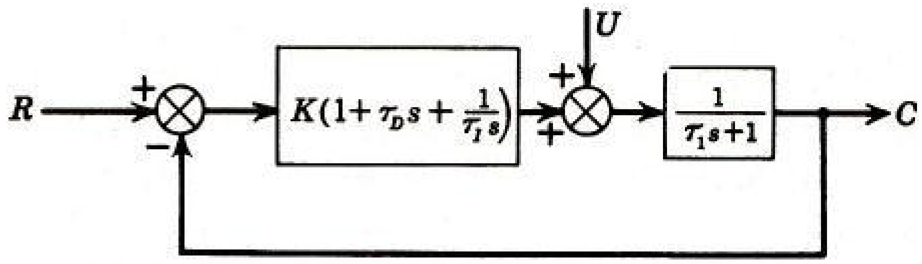


Figure 2

Q3. Q3. (a) For the control system shown in Fig. 3 , obtain the closed loop transfer function C/U.

(b) Find the value of K_C for which the closed loop response has a C of 2.3.

(c) find the offset for a unit-step change in U if K_C = 4.

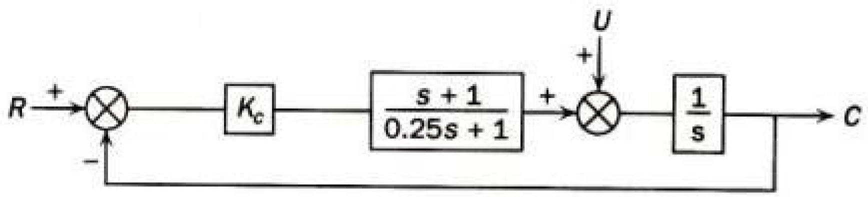


Figure 3

Q4. The thermal system shown in Fig.4 is controlled by PD controller.
Data ; w = 250 lb/min; p = 62.5 lb/ft^3 ; V_1 = 4 ft^3 ,V_2 =5ft^3 ; V_3 =6ft^3 ; C = 1 Btu/(lb)(°F)

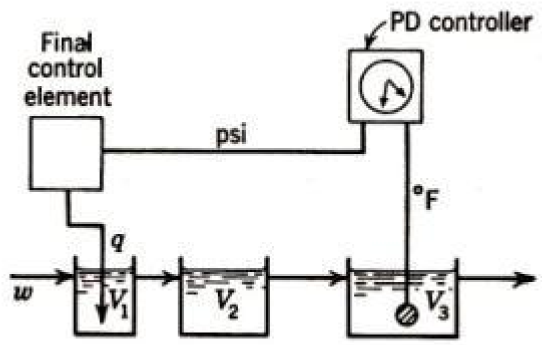


Figure 4

Change of 1 psi from the controller changes the flow rate of heat of by 500 Btu/min. The temperature of the inlet stream may vary. There is no lag in the measuring element.

(a) Draw a block diagram of the control system with the appropriate transfer function in each block. Each transfer function should contain a numerical values of the parameters.

(b) From the block diagram, determine the overall transfer function relating the temperature in tank 3 to a change in set point.

(c) Find the offset for a unit step change in inlet temperature if the controller gain K_C is 3psi/°F of temperature error and the derivative time is 0.5 min.

Department of Chemical Engineering
Assignment No.4

Subject: Process Control Semester: 6th, Chemical Engineering

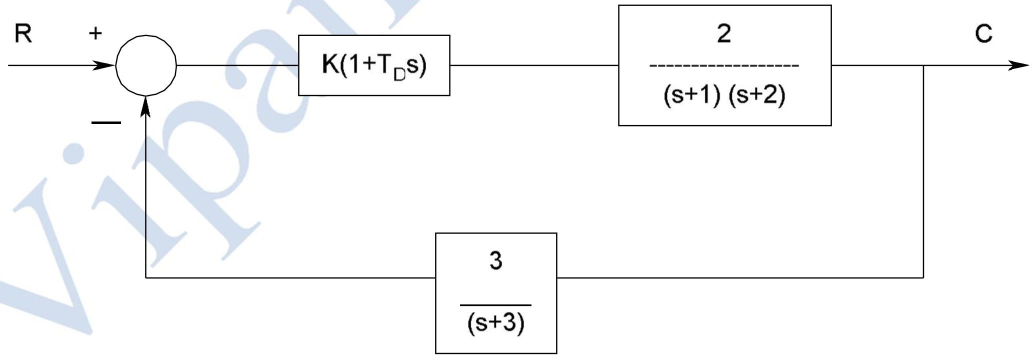
Q1. A first-order process with a dead-time has a transfer function: $G(s) = 5e^{-t_d s} / 0.2s + 1$

The process is to be controlled with a PI controller. Use the Bode stability criterion to find the range of values for the gain K c as a function of t_d, so that the closed-loop response is stable. Take τ_I = 0.5 min.

Q2. Draw the root locus of a closed loop system with the following characteristics:
Process: Gp (s) = 5/ (s+2) (2s+3)
Controller: Gc (s) = K c
Measuring Device: Gm (s) = 1.
Final Control element: Gf (s) = 1.
Find the values of Kc, for which the system is stable.

Q3. Derive expressions for amplitude ratio and phase angle as functions of ω for the transfer function $G(s) = \frac{1}{s^2 - 1}$

Q4. Draw the root-locus diagram for the following control system. (a) Determine the value of K needed to obtain a root of the characteristic equation of the closed-loop response which has an imaginary part 0.75. (b) Using the value of K found in part (a), determine all the other roots of the characteristic equation from the root-locus diagram.



Department of Chemical Engineering
Assignment No.5

Subject: Process Control Semester: 6th, Chemical Engineering

Q1. What is meant of process identification? State the advantageous of process identification. Explain the different methods used in process identification.

Q2. Obtain the Bode plot for the system with the following open loop transfer function:

$$G(s) = \frac{K(s+1)}{s(0.1+1)(0.5s+1)}$$

Q3. Obtain the transfer function of Feed Forward Controller, when $G(s) = \frac{K_p}{Ts+1}$ and $G_U = \frac{K_U}{T_U s+1}$

Q4. A paper unit is designated to produce between 1500-2000Kg/hr of a mixture of 50 wt% of softwood pulp, 2 wt% of an additive and 1 wt% of a dye. Compute the gains of the signals. The flow meter are magnetic flow meter, hence output signal is linearly related to the mass of flow rate. Specify the gains of flow transmitter if they convert mass flow rate signal to a 4 to 20 mA signal.